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P01/7700 0.00-0212631.6

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# 1/77

## Request for grant of a patent

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1. Your reference — P/63665.GBA/V/SD

2. Patent application number *(The Patent Office will fill in this part)* — 0212631.6

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   Marconi Applied Technologies Limited
   One Bruton Street
   London
   W1X 8AG

   Patents ADP number *(if you know it)* — 780351300l

   If the applicant is a corporate body, give the Country/state of its incorporation — United Kingdom

4. Title of the invention — GAS SENSORS

5. Name of your agent *(if you have one)* — N. Hucker

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   Marconi Intellectual Property
   Marrable House
   The Vineyards
   Great Baddow
   Chelmsford
   Essex CM2 7DS

   Patents ADP number *(if you know it)* — 822524500l

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

| Country | Priority application number *(if you know)* | Date of filing *(day / month / year)* |
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| | | |

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

| Number of earlier application | Date of filing *(day / month / year)* |
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| | |

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
   *a) any applicant named in part 3 is not an inventor, or*
   *b) there is an inventor who is not named as an applicant, or*
   *c) any named applicant is a corporate body.*
   *See note (d))*

   YES



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| Priority documents | (0) |
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| Statement of inventorship and right to grant of a patent *(Patents Form 7/77)* | (0) |
| Request for preliminary examination and search *(Patents Form 9/77)* | 1 |
| Request for substantive examination *(Patents Form 10/77)* | (0) |
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11. I/We request the grant of a patent on the basis of this application.

Signature Nerys Hucker Date 31/05/02

12. Name and daytime telephone number of person to contact in the United Kingdom: Nerys Hucker 01245 493 493 ext.3122

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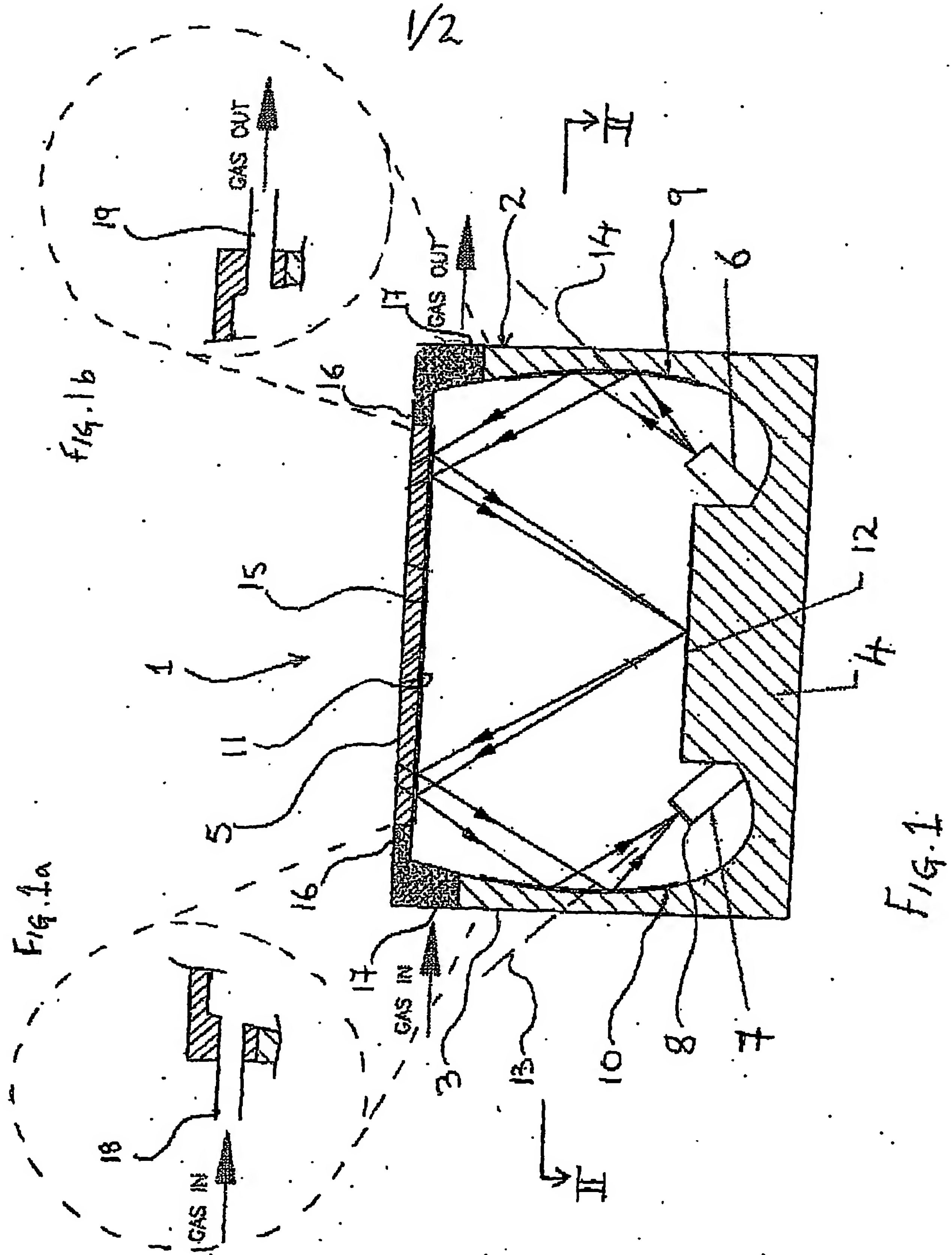


FIG. 1b

FIG. 1a

FIG. 1

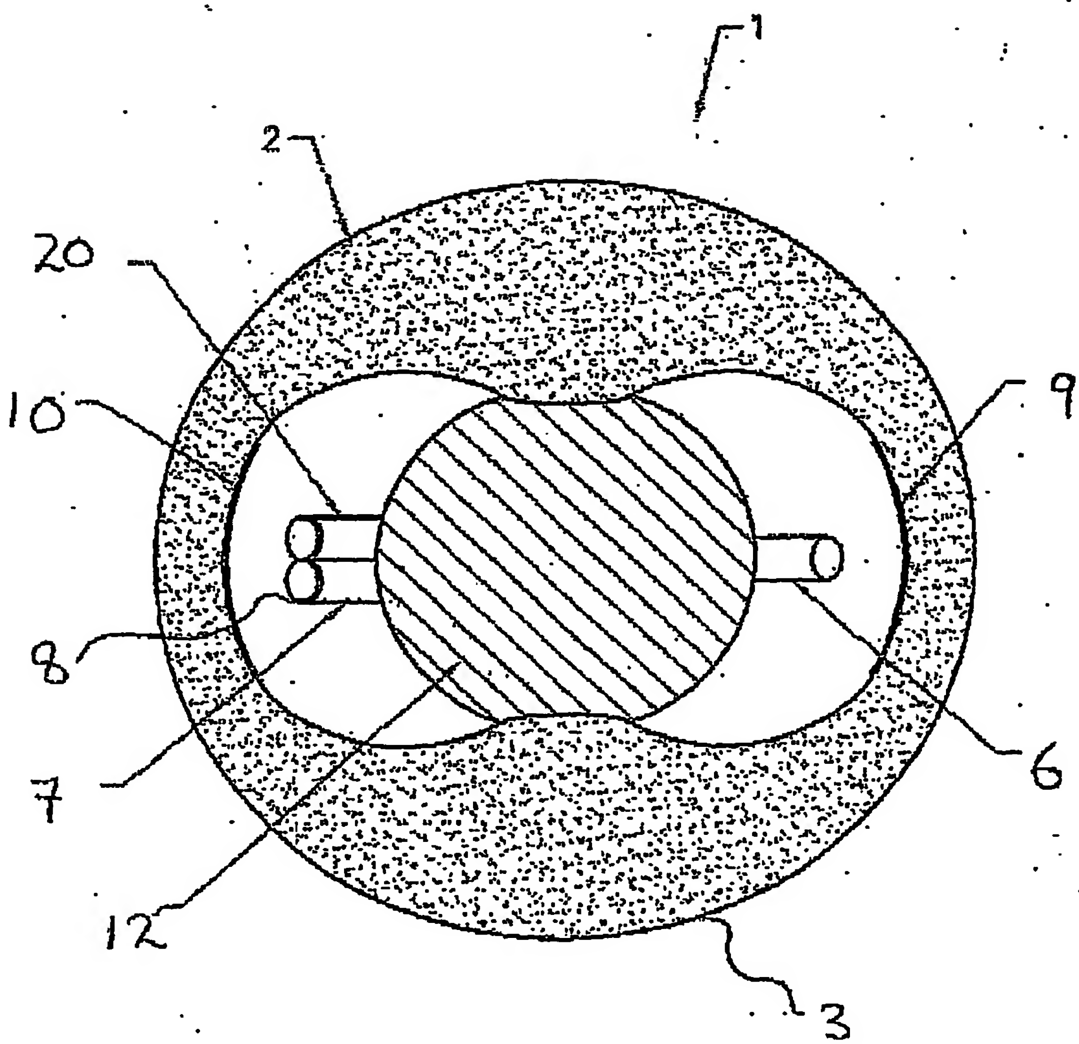


FIG. 2

DUPLICATE



# GAS SENSORS

This invention relates to apparatus for, and methods of, sensing gasses. The invention particularly relates to such methods and devices in which optical radiation is transmitted through a gas and subsequently detected to provide information concerning the gas.

In a typical gas monitor, an infrared source is arranged to emit radiation, which passes through a gas to be monitored. Infrared radiation is absorbed by the gas and that remaining is subsequently detected by an infrared detector, such as a photodiode, thermopile or pyroelectric detector. A comparison is made between the source intensity and the intensity of radiation detected following passage through the gas to give the concentration of a target gas. The concentration is related to the intensity by the following equation:

$$I = I_0 e^{-ecl}$$

where I is the intensity of radiation detected by the detector, $I_0$ is the intensity of radiation emitted at the source, e is effectively a constant which is dependent on the particular gas being monitored, c is the gas concentration and l is the distance travelled by the radiation through the gas.

The present invention seeks to provide a gas monitor having improved characteristics over those previously known.

The invention provides a gas sensor comprising a chamber arranged to admit gas, an optical source and detector means sensitive to light from the source, the detector means including a filter, wherein the detector means is arranged to detect light from a predetermined directional range.

The provision of a directional detector improves performance of the sensor, because the performance of the filter is much improved when receiving radiation from a predetermined directional range, for example a narrow solid angle centred at normal incidence. Furthermore, the sensor can be configured so that the detector collects radiation that has travelled predetermined optical paths. Thus, little of the radiation reaches the detector by means of undesired optical paths, thereby improving the signal-to-noise ratio of the sensor and leading to a more accurate determination of gas concentration, particularly at low levels.

Preferably, the source is configured to emit optical radiation in a predetermined directional range, such as a narrow solid angle at near normal incidence.

The provision of a directional source enables the sensor to be configured so that a large proportion of radiation is directed towards the detector along predetermined optical paths. Thus, even less of the radiation is scattered or reaches the detector by other optical paths, further improving the signal-to noise ratio of the sensor.

Advantageously, the directional ranges, such as the solid angles, are co-axial with the axis of the source and detector respectively.

The invention is particularly useful when employed in a gas sensor described by our British patent No. 2316172. This patent describes a gas sensor comprising a housing containing an infrared source and a detector, which are placed at the foci of respective ellipsoidal surfaces. Truncated ellipsoids provide a folded optical path for radiation from the source. Employing the present invention in such a gas sensor reduces the amount of light travelling other than by a desired folded optical path.

The chamber may further include gas admittance means. The detector and source may be located in a cylindrical housing having end walls. Regions of an end wall of the housing, and possibly adjacent regions of the cylinder may provide gas admittance means.

The end wall may include a reflector for the chamber, occupying a central region of the end wall, with the gas admittance means occupying the periphery of the wall.

The optical source is preferably an infrared source but sources and detectors operating in other parts of the optical spectrum may be used in other embodiments.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which: -

Figure 1 is a sectional schematic view of a gas sensor constructed according to the invention;

Figures 1a and 1b illustrate alternative embodiments of the gas admittance regions of the sensor of Figure 1; and

Figure 2 is a plan view through II-II of Figure 1.

With reference to Figures 1 and 2, a gas sensor is shown and indicated generally by the reference numeral 1. The detector comprises a housing 2, which is preferably flameproof. The housing 2 comprises a generally cylindrical wall 3 with end walls 4 and 5. The housing 2 contains a source 6 of infrared radiation, mounted in one of the end walls 4. The housing also contains an infrared detector 7, which includes a bandpass filter 8, also mounted in the end wall 4. Portions 9 to 12 inclusive of the interior surfaces of the housing 2 are reflectors of infrared radiation. The filter 8 is arranged to be transparent to the strong fundamental absorption band of the gas being detected.

In accordance with a first aspect of the invention, the detector 7 is directional, i.e. it is arranged to detect radiation incoming from a predetermined directional range. Preferably, the directional range comprises a predetermined solid angle, which may be centred on the axis 13 of the detector. This arrangement ensures that the detector collects radiation from a narrow cone of light, the solid angle being typically 10-12°. It has been found that the bandpass characteristic of the filter 8 associated with the detector is better defined when radiation impinges on it from predetermined directions, and preferably at near-normal incidence.

The source 6 is also directional i.e. is arranged to emit radiation in a predetermined directional range. Preferably, the directional range comprises a solid angle, which may be centred on the axis 14 of the source 6. This arrangement of the source ensures that the optical radiation it emits follows predetermined optical paths, such as those illustrated in Figure 1, and is therefore more likely to be directed towards the detector. Thus, stray light from shorter or longer optical paths is reduced, thereby improving the signal-to-noise ratio of the sensor.

The arrangement of the reflective surfaces 9 to 12 and the relative positions of components of the sensor form the subject of our patent No. GB2316172. The present invention permits an improved version of that sensor to be made, because the light in the chamber follows better-defined optical paths. A benefit of the present invention is that the reflective surfaces need only be localised for those optical paths.

The reflective wall 9 in the region of the source 6 is curved in three dimensions to define a part ellipsoid, with the source 6 being placed at one of its foci. The detector 7 is located at a focus defined by the adjacent curved surface 10 which is also defines a part ellipsoid. The reflective surfaces 9 and 10 need not be continuous. The end wall 5 opposite that on which the source 6 and detector 7 are mounted includes a reflective inner surface11, which is planar. The wall 4 between the source 6 and detector 7 has a reflective region 12, which is also planar and parallel to the end wall 5.

The configuration of the reflective surfaces 9 to 12 and locations of the source 6 and detector 7 are such that infrared radiation directionally emitted from the source is directed onto the ellipsoidal surface 9. Radiation reflected from the surface 9 is then

incident on the planar surface 11 from which it is reflected and focussed on the region 12 between the source 6 and detector 7. The radiation is then directed onto the ellipsoidal surface 10 via the surface 11 to the detector 7, where it is focussed. Thus, the radiation undergoes five reflections before being received at the detector 7.

The provision of localised reflectors 9 to 12 frees up other portions of the chamber for other uses. For example, at least some of these portions may be arranged to admit the gas to be sensed. In the embodiment of Figure 1, only the central region 15 of the wall 5 need provide the planar reflector 11. Thus, peripheral regions 16 of the wall 5 may include gas diffusion regions, such as particulate filters or sintered material.

It is preferable to be able to allow as much gas as possible to diffuse into the housing 2, to increase the likelihood of a positive and rapid identification of the target gas, and a measure of its concentration. Therefore, other regions of the housing 2 may be arranged to admit gas. For example, regions 17 of the cylindrical wall 3 not providing reflective surfaces for the light may include particulate filters, mesh or sintered material. The regions 16 in the top wall 5 and the regions 17 in the cylindrical wall 3 may be joined together to form shoulders of diffusion material, which may extend around the circumference of the detector 1.

Figures 1a and 1b illustrate alternative gas admittance means. In this embodiment, an inlet port 18 and an outlet port 19 are provided, through which gas may be directed to pass into the housing 2. The ports 18, 19 are embedded in diametrically opposite sides of the cylindrical wall 3.

The housing 2 also includes a reference detector 20 (shown in Figure 2), which is located adjacent to the detector 7 and used to compensate for changes in operating conditions and with time. The reference detector 20 includes a different filter to that fitted in the active detector 7 and does not respond to the target gas. By comparing the signals from the active detector 7 and the reference detector 20, the user can discriminate the signal reduction due to the target gas, from that due to ambient and physical variations. The reference detector 20 is preferably located immediately adjacent the active detector 7 so that the detector and reference collect radiation that has travelled similar optical paths. To aid this, the reference 20 and detector 7 may be contained in a single detector package.

A suitable infrared source is a tungsten lamp with a directional reflector, which provides a directional broadband infrared thermal source. Other sources include LEDs or lasers employed in conjunction with directional reflectors. Alternatively, diodes with immersion lenses may be employed.

The reflective surfaces may comprise layers of plated gold to provide good reflectance.

The length of the optical path through the chamber may be altered by adjusting the angle of tilt of the detector and source. Further alterations in optical path length may be achievable by adjusting the separation between the planar reflective surfaces 11, 12. Alternatively, or additionally, the dimensions of the inner surfaces of the chamber

may be changed so that the ellipsoids they represent are of different sizes or have a different angular separation.

The chamber may be a single component or may comprise a plurality of pieces. A suitable manufacturing process for the contours of the chamber is that of machine turning. Alternatively, moulding in plastics or metal injection may be utilised. These processes are well known industrial techniques and may be readily employed by the skilled person.

The invention may be used in conjunction with more than one detector, as described in our co-pending patent application, given the reference P/63675/VISD in the records of our Patent Department.

CLAIMS

1. A gas sensor comprising a chamber arranged to admit gas, an optical source and detector means sensitive to light from the source, the detector means including a filter, wherein the detector means is arranged to detect light from a predetermined directional range.

2. A sensor as claimed in claim 1, wherein the predetermined directional range comprises a predetermined solid angle.

3. A sensor as claimed in claim 2, wherein the detector means has an axis and the solid angle is substantially centred on the axis.

4. A sensor as claimed in claim 1,2 or 3, wherein the optical source is arranged to emit light in a predetermined directional range.

5. A sensor as claimed in claim 4, wherein the predetermined directional range comprises a predetermined solid angle.

6. A sensor as claimed in claim 5, wherein the optical source has an axis and the solid angle is substantially centred on that axis.

7. A sensor as claimed in any previous claim, further comprising reflector means having reflective surfaces in portions of the chamber.

8. A sensor as claimed in claim 7, wherein at least one other portion of the chamber comprises means for admitting gas into the chamber.

9. A sensor as claimed in claim 8, wherein the gas admittance means includes sintered material.

10. A sensor as claimed in claim 8, wherein the gas admittance means includes a particulate filter.

11. A sensor as claimed in any one of claims 7 to 10, wherein the reflector means comprises curved surfaces defining the foci at which the source and detector are located and a planar reflective surface defining part of an optical path between them.

12. A sensor as claimed in any preceding claim, wherein the source is at a focus of a first part ellipsoidal surface and the detector is at a focus of a second part ellipsoidal surface and the first and second ellipsoids share a common virtual focus.

13. A sensor as claimed in any preceding claim wherein the source and detector are contained within a flameproof housing.

14. A sensor as claimed in claim 13, wherein the housing comprises a cylinder having end walls.

15. A sensor as claimed in claim 14, wherein the source and detector are mounted on a common first end wall of the housing.

16. A sensor as claimed in claim 15, wherein the second end wall includes a planar reflector and gas admittance means.

17. A sensor as claimed in claim 16, wherein the planar reflector comprises a central region of the second end wall and the gas admittance means comprises a peripheral region of the second end wall.

18. A sensor as claimed in claim 17, wherein the gas admittance means further includes a region of the cylinder adjacent the second end wall.

19. A sensor as claimed in any preceding claim wherein the optical source is an infrared source.

20. A sensor as claimed in any preceding claim wherein the source is arranged to heat substantially all the surfaces from which light is reflected to a temperature above ambient temperature.

21. A gas sensor, substantially as hereinbefore described, with reference to, or as illustrated in, the accompanying drawings.